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By Precipitation as Nitrates

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE
UNIVERSITY OF MICHIGAN

By
Edwin W. Goodspeed
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Separation of Strontium, Barium, and Lead from Calcium and Other Metals

By Precipitation as Nitrates

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IN THE quantitative separation of strontium from calcium there has always been considerable difficulty due to the fact that most of the properties of strontium are very closely related to those of calcium. Thus, although the determination of either strontium or calcium alone is easily carried out, the task of determining them when taken together presents greatly increased difficulty.

By extracting the mixture of anhydrous nitrates with absolute alcohol, in which strontium nitrate is not very soluble, Stromeier (5) separated strontium from calcium. Rose (4) improved this method by using a mixture of equal parts of absolute alcohol and anhydrous ether, in which strontium nitrate is much less soluble than in alcohol alone. With certain modifications introduced by Fresenius (1), this method is the one most used today. Rawson (3) suggested the use of concentrated nitric acid as the extracting solvent.

Since precipitation methods are known to be superior to extraction methods, both in accuracy and ease of manipulation, it seemed desirable to develop such a method for the separation of strontium from calcium and other metals.

Preparation and Standardization of Solutions

c. p. strontium nitrate was dissolved in water and filtered to remove any insoluble impurities. The strontium was precipitated as the nitrate by the slow addition, with stirring, of enough 70 per cent nitric acid to bring the acid concentration of the solution up to about 40 per cent. The strontium nitrate was filtered off, washed with 40 per cent nitric acid, dissolved, and then reprecipitated a second time in a similar manner. The solution of strontium nitrate was standardized by pipetting 10-ml. samples into weighed crucibles, adding a few drops of nitric acid, and evaporating to dryness on a very low-temperature hot plate.

The strontium nitrate was then dried 2 hours at 130° to 140° C., and weighed. This standardization was checked by precipitating 10-ml. samples as the sulfate with a tenfold excess of sulfuric acid from a 50 per cent alcohol solution. After standing 12 hours, the precipitate of strontium sulfate was filtered through a Gooch crucible and dried 1 hour in a muffle heated to 500° C. The results obtained by the two methods agreed within 0.1 mg.

Solutions of barium nitrate and lead nitrate were purified in a similar manner and standardized by evaporating to dryness and weighing as the nitrates.

The calcium nitrate solution was prepared from reagent quality calcium carbonate by dissolving it in dilute nitric acid. It was purified by adding 100 per cent nitric acid until the acid concentration was 80 or 81 per cent, the volume being such that a small amount of calcium nitrate was precipitated. After standing 0.5 hour the precipitated calcium nitrate (along with any barium or strontium nitrates that might have been present) was filtered off and discarded. The filtrate was evaporated to dryness to remove the nitric acid, and the calcium nitrate was then dissolved in water. The solution was standardized by precipitating 10-ml. samples as oxalate, followed by ignition at 500° C. to the carbonate.

Although fuming nitric acid as purchased could be used successfully for obtaining the desired acid concentration, in most of this work freshly prepared 100 per cent nitric acid was employed. This was prepared by distilling a mixture of c. p. sodium nitrate and c. p. concentrated sulfuric acid in an all-glass distilling apparatus, the flask having a capacity of 2 liters. A convenient charge consisted of 500 grams of sodium nitrate and 500 ml. of sulfuric acid.

Experimental

Attempts were first made to precipitate strontium nitrate from solution in an organic solvent. The general method used was to evaporate a sample of strontium nitrate to dryness with an excess of perchloric acid and dissolve the strontium perchlorate in the organic solvent. Strontium was then precipitated as the nitrate by the slow addition of a mixture of the solvent and 100 per cent nitric acid. The solvents tried were a mixture of absolute alcohol and anhydrous ether, normal butyl alcohol, a mixture of normal butyl alcohol and anhydrous ether, tertiary butyl alcohol, carbitol, and butyl carbitol. Incomplete precipitation and the formation of slimy, unfilterable precipitates caused this work to be abandoned.

It was found that dry strontium nitrate could be dissolved in a very little water and was precipitated in a dense granular form by the addition of nitric acid, whereas calcium nitrate proved to be much more soluble. The precipitate showed no tendency whatever to stick to the sides of the beaker, and was readily washed into the filtering crucible with a few jets of acid of the same concentration as that used for the precipitation.

The wash bottle was a 250-ml. Erlenmeyer flask fitted with a two-hole rubber stopper. A rubber bulb furnished the necessary air pressure. The rubber bulb and stopper are attacked slowly by the nitric acid vapors but, if rinsed after being used, they last a long time.

The solutions were filtered through Gooch crucibles with rather thick pads. The precipitates were dissolved out and the pads used repeatedly. In dissolving the precipitates, hot water with a little nitric acid proved to be more satisfactory than hot water alone, especially if metals other than strontium were present. The strontium nitrate precipitate was dried 2 hours at 130° to 140° C., but longer drying does no harm.

The concentrations of the nitric acid solutions were obtained from tables (2), after determining the specific gravity of the pure solutions by means of a hydrometer having a range of 1.4 to 1.6. (For concentrations below 70 per cent a hydrometer with a range of 1.2 to 1.4 was used.) A few specific gravity determinations were made with a pycnometer and the values were found to check those obtained by the hydrometer method within 0.002. We may assume, then, that the acid concentration is always within 1 per cent of the stated value, and usually within 0.5 per cent.

Precipitations were first made by dissolving the dry salts in a definite volume of water, adding a known amount of 70 per cent (ordinary concentrated) nitric acid, which caused most of the strontium nitrate to precipitate, and then adding a definite amount of 100 per cent nitric acid to bring the acid concentration to the desired value. It was simpler, however, to dissolve the dry salts in a definite volume of water and add enough 100 per cent nitric acid, drop by drop, with constant stirring, to bring the acid concentration up to the desired value. This was determined by adding to the proper volume of water increasing amounts of acid and determining the specific gravity with a hydrometer, applying a temperature correction. It is convenient to make all the additions from a buret. If 70 per cent nitric acid is used, each bottle must be tested, likewise the c. p. fuming nitric acid of commerce.

Precipitation was complete within 30 minutes, except that for very small amounts it was necessary to stir the solution mechanically for 45 minutes.

EFFECT OF VARYING ACID CONCENTRATION. In determining the effect of acid concentration all precipitates stood 0.5 hour or more before filtering, were transferred and washed with about 18 ml. of acid of the same concentration as that used during the precipitation, were then dried for 2 hours at 130° to 140° C., and weighed. The volume during precipitation was about 18 ml. The results are shown in Table I.

As an additional check the filtrates and washings were evaporated to dryness and taken up with water. Any barium or strontium present was precipitated as sulfate, the latter from a 50 per cent alcohol solution. No barium sulfate could be detected in the filtrates from acid concentrations of 76 per cent or higher. With strontium a very faint turbidity was noticed with 70 per cent acid, less with 80 per cent, and none with higher concentrations. In the case of lead, noticeable precipitates were obtained with ammonium sulfide in all filtrates up to, and including, the 80 per cent acid. In the others no precipitate settled out, but the solutions darkened considerably. There was no difference in the amount of darkening between those obtained with the 83 per cent and the 87 per cent acids, but that with the 82 per cent was somewhat darker. In general, the solubility of lead nitrate in 84 per cent nitric acid corresponds to about 0.1 mg. of lead per 20 ml. The solubility increases considerably with higher tem-

peratures, but is reduced to a negligible amount when the solution is cooled in ice. It would seem, then, that 76 per cent nitric acid suffices for barium, but 80 per cent acid is required for strontium, and 84 per cent for lead.

TABLE I. EFFECT OF ACID CONCENTRATION ON PRECIPITATION OF STRONTIUM, BARIUM, AND LEAD NITRATES

(All precipitations were made in a volume of about 18 ml. at 20° to 25° C. The precipitates were transferred and washed with about 18 ml. of acid of the same concentration as that used for the precipitation.)

Acid, per cent	66	69	74	78	80	83	85	87
Sr found, error, mg. (57.9 mg. taken in each case)	...	-1.3	-0.3	0	0	+0.1	0	...
Ba found, error, mg. (56.6 mg. taken in each case)	...	-1.7	-0.3	-0.1	0	0	0	...
Pb found, error, mg. (101.7 mg. taken in each case)	-0.8	...	0	0	0	0	..	0
	-0.9	...	-0.1	-0.1	-0.1	-0.1	..	-0.1
	-8.8	...	-1.3	-0.9	-0.2	-0.2	..	-0.1
	-9.5	...	-1.4	-0.7	-0.4	-0.1	..	-0.1

Using 77 per cent nitric acid, in which the solubility of strontium nitrate is appreciable, a comparison of the solubility of strontium nitrate in both the precipitating and the wash solutions was made. About 140 mg. of strontium nitrate were dissolved in a little water and the acid concentration was brought up to 77 per cent, the volume being 100 ml. After standing 0.5 hour the precipitate was filtered off and the strontium in the filtrate was determined as sulfate. The precipitate in the crucible was then washed with 100 ml. of 77 per cent nitric acid, and the strontium determined in the washings. The strontium sulfate in each case weighed 0.7 mg., indicating that the wash solution becomes saturated with the nitrate.

EFFECT OF TEMPERATURE. Since the separation of strontium from certain metals might be improved by an increase in temperature, a few determinations were made at 50° and 70° C., these temperatures being maintained for 0.5 hour after precipitation, when the solution was filtered and washed with acid at room temperature. The results in Table II show that temperatures up to 70° C. may be used without causing loss of strontium nitrate. Temperatures above 70° C. were not tried, because above this the nitric acid fumes off rather rapidly.

TABLE II. PRECIPITATION OF STRONTIUM NITRATE AT VARIOUS TEMPERATURES FROM 80 PER CENT NITRIC ACID

[Sr(NO ₃) ₂ taken, 149.3 mg. = 61.8 mg. of Sr]		
Temperature ° C.	Sr(NO ₃) ₂ Found Mg.	Error, Sr Mg.
25	149.6	+0.1
	149.4	0
	149.2	0
50	149.2	0
	149.2	0
	149.5	+0.1
70	149.5	0
	149.4	0

EFFECT OF OTHER ANIONS. No effort was made to determine an all-inclusive list of anions that might be present in the determination of strontium. However, as it was felt

that chloride and perchlorate would be frequently encountered, tests were made in their presence. The amounts of these acids taken were greatly in excess of that required to convert all the strontium to chloride and perchlorate, and were added after evaporation to dryness, so that the full amount of acid was present during precipitation. Precipitation was made in 80 per cent nitric acid in a volume of 18.2 ml. Upon taking 0.75 ml. of concentrated hydrochloric acid and 139.9 mg. of strontium nitrate, 140.0 and 140.1 mg. of strontium nitrate were found. When 149.3 mg. of strontium nitrate were taken with 0.75 ml. of 70 per cent perchloric acid, 149.5 and 149.3 mg. of strontium nitrate were found.

Evidently these ions exert no harmful effect on the determination of pure strontium.

TABLE III. SOLUBILITY OF CALCIUM NITRATE IN NITRIC ACID

Acid Concentration %	Calcium Dissolved Mg./ml.
77	26.5
79	10.0
81	5.0
83	1.9
85	1.1

SOLUBILITY OF CALCIUM NITRATE IN NITRIC ACID. The solubility of calcium nitrate in nitric acid of various concentrations was determined by putting an excess of finely pulverized calcium nitrate in glass-stoppered cylinders containing the nitric acid. The mixture was kept in a thermostat at 25° C. for several hours with frequent shaking. Samples of 50 ml. were pipetted out, the nitric acid was evaporated, and the calcium determined by precipitation as the oxalate followed by ignition at 500° C. to the carbonate. The results, shown in Table III, indicate that as low an acid concentration as possible should be used in separating strontium from calcium.

Separation of Strontium from Calcium

It was found essential to add the nitric acid drop by drop with constant stirring, in order to avoid carrying down appreciable amounts of calcium. Separations of strontium made by the addition of the acid in a stream from a buret with a little stirring gave results 1.7 mg. too high, while identical separations made with drop-by-drop addition of the acid with constant vigorous stirring gave correct results.

The greater the volume of the solution at the time of precipitation, the better are the separations obtained. However, because of the slight solubility of strontium nitrate and the greater ease in transferring the precipitate from a small beaker, total volumes under 40 ml. were usually employed and a 50-ml. beaker was used. Best results were obtained by precipitating the bulk of the strontium with 70 per cent nitric acid and then using 100 per cent acid to bring the

concentration up to the desired value. However, it is simpler to eliminate the use of the 70 per cent acid, and results practically as good may be obtained using only 100 per cent acid, provided it is added very slowly and with vigorous (preferably mechanical) stirring. A solution in which the acid concentration is 80 per cent may be obtained by dissolving the salt in 10.0 ml. of water and adding 26.0 ml. of 100 per cent nitric acid.

Separations were made in which the time of standing after precipitation was varied from 0.5 to 5 hours. There is a slight downward trend in the amount of calcium carried down as the time of standing is lengthened. Evidently on standing some of the co-precipitated calcium nitrate is gradually dissolved.

Separations were tried at elevated temperatures, but no appreciable advantage is gained by precipitating hot.

Separations were made using various acid concentrations. As was to be expected, the lower acid concentrations gave better separations, but any concentration in the range of 79 to 81 per cent is satisfactory. Above 81 per cent the solubility of calcium nitrate is too small, and below 79 per cent the solubility of strontium nitrate becomes appreciable.

TABLE IV. SEPARATION OF STRONTIUM FROM CALCIUM

Sr Mg.	Taken Ca Mg.	First Precipitation		Second Precipitation	
		Found, Sr Mg.	Error, Sr Mg.	Found, Sr Mg.	Error, Sr Mg.
2.1 ^a	50	2.8	+0.7	2.0	-0.1
		2.8	+0.7	2.0	-0.1
		3.2	+1.1	2.3	+0.2
2.1 ^{a,b}	500	4.0	+1.9	2.3	+0.2
		2.1	0	2.0	-0.1
2.1 ^a	None	2.1	0	2.0	-0.1
		12.9	+0.5	12.4	0
12.4	50	12.8	+0.4	12.3	-0.1
		12.4	0	12.3	-0.1
12.4	None	12.3	-0.1	12.3	-0.1
		62.0	+0.3	61.5	-0.2
61.7	50	61.9	+0.2	61.6	-0.1
		61.7	0	61.6	-0.1
61.7	None	61.7	0	61.7	0
		154.6	+0.2	154.2	-0.2
154.4	50	154.5	+0.1	154.2	-0.2
		154.4	0	154.4	0
154.4	None	154.4	0	154.3	-0.1
		929.7	+1.0	928.7	0
928.7	50	929.9	+1.2	928.7	0
		928.8	+0.1	928.7	0
928.7	None	928.6	-0.1	928.6	-0.1
		61.7	0		
61.7	25	61.7	0	Second pptn. not needed	
		82.7	+1.0		
61.7	125	62.7	+1.0	61.6	-0.1
		65.7	+4.0	61.7	0
61.7 ^b	500	65.3	+3.6	61.8	+0.1
		61.6	-0.1	61.7	0
61.7 ^b	None	61.6	-0.1	61.5	-0.2
		61.6	-0.1	61.6	-0.1

^a Mechanically stirred for 45 minutes after precipitation.

^b 30 ml. of water and 78 ml. of 100 per cent nitric acid, giving 80 per cent acid for the first precipitation; second precipitation, 10 ml. of water, 26 ml. of 100 per cent acid.

Table IV shows the results of some separations of strontium from calcium. The dry nitrates were dissolved in 10.0 ml. of water, and the strontium nitrate was precipitated by adding 26.0 ml. of 100 per cent nitric acid drop by drop with mechanical stirring. This gave an acid concentration of 80 per cent.

After the addition of the acid the solution stood 0.5 hour, before filtering through Gooch crucibles, the precipitate being transferred with jets of 80 per cent nitric acid, then washed 10 times in the crucibles with approximately 1-ml. portions of 80 per cent nitric acid. The strontium nitrate was dried 2 hours at 130° to 140° C. In making double precipitations the precipitates were dissolved directly into a beaker placed under a bell jar, using hot water which had been slightly acidified

TABLE V. SEPARATION OF STRONTIUM FROM VARIOUS METALS

[In each case $\text{Sr}(\text{NO}_3)_2$ taken, 149.3 mg. = 61.8 mg. of Sr]

Salt Added	Metal Content Mg.	Error, Sr Mg.
$\text{Al}(\text{NO}_3)_3$	25	+0.2
		0
$\text{Al}(\text{NO}_3)_3$	75 ^a	-0.1
		0
NH_4NO_3	500	-0.1
		+0.1
SbCl_3	500 ^b	+0.1
		0
H_3AsO_4	500	-0.1
		+0.2
$\text{Be}(\text{NO}_3)_2$	500	+0.2
		0
$\text{Bi}(\text{NO}_3)_3$	500	-0.2
		+0.2
$\text{Ca}(\text{NO}_3)_2$	25	+0.1
		0
$\text{Cd}(\text{NO}_3)_2$	500	-0.1
		+0.5
$\text{Ce}(\text{NO}_3)_4$	500	+0.5
		+0.1
$\text{Cr}(\text{NO}_3)_3$	100	+0.1
		+0.1
$\text{Co}(\text{NO}_3)_2$	500	0
		0
$\text{Cu}(\text{NO}_3)_2$	250	+0.1
		+0.1
$\text{Cu}(\text{NO}_3)_2$	500 ^a	0
		-0.1
$\text{Fe}(\text{NO}_3)_3$	500	-0.1
		0
$\text{La}(\text{NO}_3)_3$	500	+0.1
		0
LiNO_3	150	-0.1
		-0.1
$\text{Mg}(\text{NO}_3)_2$	500	0
		+0.1
$\text{Mn}(\text{NO}_3)_2$	500	0
		+0.1
$\text{Hg}(\text{NO}_3)_2$	500	0
		0
$\text{Ni}(\text{NO}_3)_2$	2000	0
		+0.5
KNO_3	500	+0.4
		+0.1
H_2SeO_3	500	0
		+0.2
AgNO_3	150	+0.2
		+0.3
NaNO_3	300	+0.2
		0
H_2TeO_3	75	0
		0
TiCl_3	500	+0.1
		+0.1
TiNO_3	500	+0.2
		0
SnCl_4	500	-0.1
		0
$\text{UO}_2(\text{NO}_3)_2$	500	0
		+0.1
$\text{Zn}(\text{NO}_3)_2$	500	0

^a Precipitated at 70° C.

^b 1.5 ml. of HCl added.

with nitric acid. In each case pure strontium was carried through the same process to ensure that the results obtained were not due to compensating errors.

Various amounts of strontium may be separated from 25 mg. of calcium with only one precipitation. If more than 25 mg. of calcium are present double precipitations are necessary, and if the amount of calcium is very large the volume of the solution must be increased.

Separation of Strontium from Metals Other than Calcium

Solutions of many metals were made up, usually from the nitrates. The solutions were made from c. p. chemicals, and as first prepared were not purified in any way. If high results were obtained in a separation, the solution of the metal was purified by treatment with 80 per cent nitric acid, filtering off any precipitate that was obtained. The solutions were not analyzed as to metal content, but were probably accurate to within 10 per cent.

Generally the dry salts were dissolved in 3.0 ml. of water and precipitated with 5.5 ml. of 71 per cent nitric acid, and the concentration was brought to 80 per cent by the addition of 10.0 ml. of 100 per cent nitric acid. The precipitate was allowed to stand 0.5 hour, and then was transferred and washed with about 18 ml. of 80 per cent nitric acid, after which it was dried for 2 hours at 130° to 140° C.

Solution of the salts in 3.0 ml. of water was readily accomplished by adding 1.0 ml. of 71 per cent nitric acid and heating a few minutes. In the list of metals separated from strontium, the only ones which could not be dissolved in this volume were 500 mg. of beryllium nitrate, 500 mg. of ferric nitrate, and 2000 mg. of nickel nitrate. For these amounts of beryllium, iron, and nickel, larger initial volumes were used, the amount of 71 per cent acid being decreased, and the 100 per cent increased, in order to keep the final volume the same.

In the case of antimony and tin, as it was found advantageous to have some hydrochloric acid present, the salts were dissolved in a mixture of 1.5 ml. of water and 1.5 ml. of concentrated hydrochloric acid.

TABLE VI. SEPARATION OF BARIUM FROM VARIOUS METALS

[In each case Ba(NO ₃) ₂ taken, 107.7 mg. = 56.6 mg. of Ba]			
Salt Added	Metal Content	Ba(NO ₃) ₂ Found	Error, Ba
	Mg.	Mg.	Mg.
Bi(NO ₃) ₃	500	107.7	0
		107.6	0
		107.9	+0.1
Ca(NO ₃) ₂	125	107.6	0
		107.9	+0.1
Cd(NO ₃) ₂	500	107.7	0
		107.8	0
Ni(NO ₃) ₂	500	107.8	0
		107.6	0
Pure Ba(NO ₃) ₂	...	107.5	-0.1

Nearly all precipitations were made at room temperature but in some cases a large temperature effect was noticed. This was especially true with copper and aluminum, so a few separations from these metals were made at 70° C. The solutions were allowed to stand for 0.5 hour at the same temperature, after which they were filtered through a warm crucible and washed with acid at room temperature.

The metals from which separations were made, as shown in Table V, are the largest amounts possible in a volume of 18.5 ml. of 80 per cent nitric acid, with the exception of those metals from which the separation of 500 mg. or more was possible. No amounts greater than 500 mg. were tried except in the case of nickel, where the maximum used was 2000 mg. If larger volumes were used, separations from larger amounts of the metals would be possible.

The only metal tried from which strontium could not be separated was titanium (except for barium and lead which were quantitatively precipitated).

RECOMMENDED PROCEDURE. Evaporate the metallic chloride, perchlorate, or nitrate (preferably the latter) to dryness; dissolve in 10.0 ml. of water; precipitate the strontium nitrate by adding 26.0 ml. of 100 per cent nitric acid, drop by drop, with constant (preferably mechanical) stirring; allow to stand 0.5 hour; filter through a Gooch crucible, transferring the precipitate with a jet of 80 per cent nitric acid, and washing ten times with acid of the same concentration, using about 1 ml. each time; dry at 130° to 140° C. for 2 hours; weigh as $\text{Sr}(\text{NO}_3)_2$. Larger volumes and double precipitations may be used if necessary.

Determination of Barium and Separation from Other Metals

The precipitate of barium nitrate is of the same dense crystalline form that characterizes strontium nitrate, and it is reasonable to assume that barium may be separated from all the metals from which strontium may be separated. Since a lower acid concentration may be used for barium, even better separations would probably be possible. Table VI shows the results of a few separations that were made.

The dry salts were dissolved in 5.0 ml. of water. The barium nitrate was partially precipitated by the slow addition, with stirring, of 3.0 ml. of 70 per cent nitric acid, after which 11.0 ml. of 100 per cent acid were added in the same manner to bring the acid concentration up to 76 per cent. After standing 0.5 hour the barium nitrate was filtered off, washed ten times with 76 per cent nitric acid, and dried for 2 hours at 130° to 140° C.

It did not seem necessary to try other separations. Barium can undoubtedly be separated from all the metals from which strontium was separated (Table V).

Determination of Lead and Separation from Other Metals

Table VII shows the results of a few separations of lead from various metals.

The dry salts were dissolved in 2.5 ml. of water, and the acid concentration was brought to 84 per cent by the drop-by-drop addition of 5.0 ml. of 70 per cent nitric acid and 13.0 ml. of 100 per cent acid. After standing 0.5 hour at room temperature, the lead nitrate was filtered off, washed ten times with small portions of 84 per cent nitric acid, and dried for 2 hours at 135° C.

Because the presence of chloride gives low results in the determination of lead, this must be absent. This fact prevents the separation of lead from antimony and tin. A separation from all the other metals shown in Table V would no doubt be possible.

In some cases at least, separations are made from highly supersaturated solutions of the metals. For instance, in the separation of lead from copper, a crystal of copper nitrate was added to the filtrate and caused a large amount of copper nitrate to precipitate. This was filtered, dried, and with an indefinite amount of water of crystallization weighed 0.7 gram.

TABLE VII. SEPARATION OF LEAD FROM VARIOUS METALS

[In each case $\text{Pb}(\text{NO}_3)_2$ taken, 162.5 mg. = 101.7 mg. of Pb]

Salt Added	Metal Content Mg.	$\text{Pb}(\text{NO}_3)_2$ Found Mg.	Error, Pb Mg.
H_2AsO_4	500	162.3	-0.1
		162.4	-0.1
		162.7	+0.1
$\text{Bi}(\text{NO}_3)_3$	500	162.9	+0.2
		163.0	+0.3
		162.9	+0.2
$\text{Ca}(\text{NO}_3)_2$	15	162.2	-0.2
		162.3	-0.1
		162.2	-0.2
$\text{Cd}(\text{NO}_3)_2$	500	162.2	-0.2
		162.2	-0.2
		162.4	-0.1
$\text{Cu}(\text{NO}_3)_2$	300	162.5	0
		162.4	-0.1
		162.4	-0.1
$\text{Hg}(\text{NO}_3)_2$	500	162.4	-0.1
		162.4	-0.1
		162.4	-0.1
Pure $\text{Pb}(\text{NO}_3)_2$	...	162.4	-0.1

Summary

Attempts to separate strontium from calcium by precipitation of strontium nitrate with nitric acid in organic solvents resulted in incomplete precipitation and slimy, unfilterable precipitates.

Strontium nitrate can be completely precipitated in a dense, crystalline form from a water solution, and separated from twenty-eight metals by the very slow addition of 100 per cent nitric acid until the resultant solution contains not less than 79 per cent: to separate barium from the same metals, 76 per cent acid suffices; to separate lead, 84 per cent is necessary, but chloride makes impossible a separation of lead from tin and antimony.

The precipitate should stand at least 30 minutes before filtering; if it is very small, the solution should be stirred mechanically for 45 minutes. The nitrate is dried 2 hours at 130° to 140° C.

Temperatures up to 70° C. do not increase appreciably the solubility of strontium nitrate but may increase that of other nitrates.

The solubility of calcium nitrate decreases rapidly with increasing acid concentrations. A maximum of 80 per cent acid is recommended.

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